

Site Need Statement

General Reference Information	
1 *	Need Title: Enhanced HLW/LAW Melter Operation
2 *	Need Code: RL-WT100
3 *	Need Summary: Operational issues with the HLW and LAW melters are opportunities for risk reduction and cost savings for the RPP-WTP Project. Many of them relate to the use of bubblers in the melters and the required frequency of replacement. Frequent bubbler replacement will result in added downtime and additional contamination to the melter cells. This facility contamination, if extreme, could severely impact the ability to do equipment (e.g., crane and manipulator) maintenance. Technical needs related to melter operation are separated into the three general areas described below as follows: operational data needs from West Valley Demonstration Project, processing rate, advanced corrosion-resistant materials, and noble metals accumulation mitigation.
4 *	Origination Date: FY 2001 (November 8, 2000)
5 *	Need Type: Technology Need
6	Operation Office: Office of River Protection
7	Geographic Site Name: Hanford Site
8 *	Project: Waste Treatment and Immobilization Plant Office of River Protection - Treat Waste Balance of Mission PBS No: RLORP-TW067
9 *	National Priority: ____ 1. <u>High</u> - Critical to the success of the EM program, and a solution is required to achieve the current planned cost and schedule. X 2. <u>Medium</u> - Provides substantial benefit to EM program projects (e.g., moderate to high life-cycle cost savings or risk reduction, increased likelihood of compliance, increased assurance to avoid schedule delays). ____ 3. <u>Low</u> - Provides opportunities for significant, but lower cost savings or risk reduction, may reduce the uncertainty in EM program project success.
10	Operations Office Priority:
Problem Description Information	
11	Operations Office Program Description: To perform the activities necessary to remediate the Hanford tank waste, DOE assigned responsibility to the Office of River Protection (ORP) in Richland, Washington. DOE is has extended a contract for the design, construction, and commissioning of a new Waste Treatment and Immobilization Plant (WTP) that will treat and immobilize the waste for ultimate disposal. The WTP is comprised of four major elements, pretreatment, LAW immobilization, HLW immobilization, and balance of plant facilities. ORP is scheduled to award the contract in January 2001.
12	Need/Problem Description: Operational Data Needs from West Valley Demonstration Project: <u>Long-term consequences of cell contamination due to replacement of spent melter components</u> - Currently, the basis for the RPP-WTP HLW melter design is to feed the melter without bubbling agitation. However, preliminary pilot melter testing suggests that attainment of the design-processing rate of 1.5 MT/day is not likely without bubbling. Use of bubblers to achieve higher throughput would currently involve the change out of many more components over the life of the facility, perhaps by a factor of three. It is known that the removal of melter components contaminates the cell but the long-term impact is not known. Early and extensive cell contamination could have major adverse impact on the facility's operational cost and on occupational exposures during its 40 year operating life. Descriptions of the AVH operations in the UK and in France indicated that a cell crane had become contaminated to a level of 10,000 REM. When crane maintenance was required, about six months of crane decontamination was required before it could be repaired. This caused very high total personnel doses and adversely impacted the

production facility's availability. This level of contamination was reached apparently after about 10 to 15 years of operation.

It is unclear whether this high contamination is due to calciner maintenance or the relatively high change out of the Inconel melter components or some other factor. However, an evaluation of the extent of contamination of a similar facility (West Valley Demonstration Project) to that of the RPP-WTP would provide directly applicable data to help determine if this is a concern for a long term RPP operating facility. Should unforeseen, undemonstrated and bulky remote change-out equipment be designed and used? Should costly R&D be completed to extend the longevity of equipment to minimize component change out or is this really a non-issue for liquid fed ceramic melters?

Pressure Fluctuations in the Melter and Submerged Bed Scrubber - The SBS is the reference first scrubber in the LAW and HLW vitrification off gas systems. It is known that the nature of the original design includes natural oscillation of from ± 1 to 5 inches water column. To make operations more stable with less likelihood of contaminating the cell, these pressure fluctuations were reduced with a design change and tested on a one-third scale SBS. The design change did reduce the pressure fluctuations. However, plugging of the SBS lines has occurred which may require going back to the original design. The characteristics of a unit nearer full scale is characteristics of a unit nearer full scale are desired to verify scale up and bottom distributor plate design. West Valley has an operating SBS with a known design. Characterization of the melter, SBS, SBS liquid level and SBS specific gravity pressure fluctuations would advance the understanding of the systems operations without significant additional costs. However, the West Valley instrumentation is not sufficiently responsive for making these measurements.

For advancing and improving the baseline SBS design for RPP, it is requested that a more sensitive pressure measurement system with congruent data logging be installed in parallel to West Valley's operating sensors to gather this data.

Noble Metals Accumulation Measurement - Noble metals accumulation appears to be the life limiting issue for the RPP-WTP HLW melter. The current design is based upon several assumptions about the mass fraction that accumulates and the volume concentration in the settled sludge. West Valley has completed nearly two years of operations with a noble metals concentration comparable to the RPP-WTP flow sheet. A sample of this sludge has been taken as part of the TFA effort. However, an estimate of the volume of sludge has only been speculated based upon an electrical conduction assumption. To better estimate the actual volume accumulated, measurements of the depth and distribution of the sludge in the actual melter is needed. Probing for the depth of the sludge layer from the different lid nozzles would better define the actual volume of sludge that has accumulated. This could be achieved during replacement of spent lid assemblies in the feed nozzle, thermowells, glass level, etc (nozzles A, B, BB, D, E, FF, R1 and R2).

To replicate the information already available in the West Valley melter it would take over two years and ~ \$100 million worth of operations and the cost of noble metals. Since this information drives the WTP-RPP design, the estimated volume based upon an actual operated melter could clarify the scope of the issue that needs to be address at RPP-WTP and its 40 years of operations.

Processing Rate: As discussed above, preliminary pilot melter testing suggests that attainment of the RPP-WTP HLW melter design throughput of 0.4 MT/m²/day (1.5 MT/day) is not likely without bubblers and bubbling may be required. Use of bubblers to achieve higher throughput would currently involve the change out of many more components over the life of the facility and result in greater contamination to the facility. There is a need to thoroughly evaluate, and develop if possible, alternative approaches to increasing processing rates to achieve the HLW design basis throughput and potentially exceed the design basis for enhanced throughput scenarios. A number of technical aspects of the melter operation are important to increasing melting rates, specifically monitoring systems, feed staging and blending, convective heat transfer and temperature of the melt, and cold cap chemistry. Potential areas to be investigated include feed chemistry (glass formulation, pH adjustment, redox adjustment), glass formers (glass former type, frit versus raw chemicals), water content and heat transfer to the cold cap. The RPP-WTP project is evaluating some of these variables. but does not have sufficient resources to thoroughly

	<p>investigate the issue.</p> <p>Advanced, Corrosion-Resistant Materials: Advanced materials of construction or coatings have the potential to significantly improve melter reliability and lifetime. Certain melter components are highly susceptible to corrosion including bubbler tubes, thermowells, electrodes, offgas components, and refractory. Certain of these components are considered to be consumables (e.g., bubbler tubes, thermowells, off-gas components) and will be replaced periodically in the Hanford HLW/LAW melters. The required frequency of replacement will impact time operating efficiencies and overall contamination of the melter cells. Additionally, gross contamination of the melter cells, both HLW and LAW, has the potential of compromising the operating philosophies. That is, excessive contamination of the LAW melter cell will compromise the contact handled maintenance philosophy, and gross contamination of the HLW melter cell will result in extended operating down times for decontamination/maintenance of the crane. Advanced materials of construction or coatings that extend the life of the melter components (particularly consumables) will reduce risk and save operating costs.</p> <p>The melter components are exposed to physical and chemical conditions in the molten glass and in the vapor space, and will need to be resistant to corrosion in both environments. Vapor space conditions of interest include temperatures between 400°C and 1200°C and the presence of O₂, NaCl, Na₂SO₄, and acid gases. Molten glass conditions include a nominal temperature of 1150°C, glass compositions consistent with HLW and LAW waste, and a potential Na₂SO₄ layer.</p> <p>The RPP-WTP Project is currently funding some work in this area, but it is insufficient to reasonably explore promising materials. Envisioned activities in a materials development program for this application include: definition of relevant chemical/physical environment; selection/development of candidate materials and coatings; coupon testing and examinations using SEM, EDS, XRF, and weight loss; understanding of corrosion/erosion mechanisms; and pilot-scale testing.</p> <p>Noble Metals Accumulation Mitigation: Noble metals are present in Hanford HLW in concentrations that are high enough to form insoluble particles in the melter. These particles, primarily RuO₂, may settle and accumulate in a sludge at the melter bottom. In Joule-heated ceramic melters the noble metal sludge was found to significantly alter the electrical current density distribution within the melter or even form a short circuit path between electrodes. In addition, this sludge, often containing other crystalline compounds such as spinel, may block the melter pouring assembly. A strategy must be developed to avoid the possibly catastrophic effects of noble metal accumulation in the Hanford HLW glass melters. Aspects of this strategy are likely to include: 1) determination of the acceptable concentrations of noble metals in the melter to avoid accumulation, 2) development of tools for detection of sludge formation and growth, and 3) identification of methods to remove the sludge layer or mitigate it's adverse effects. It is expected that primary emphasis will be placed on the determination of acceptable noble metal concentrations as functions of key parameters using crucible tests, modeling, and limited melter demonstrations. Past studies indicate that the variables that significantly impact sludge formation include glass composition, noble metal concentration, and processing conditions.</p>
13	<p>Functional Performance Requirements:</p> <p>Operational Data from West Valley Demonstration Project: Determine, through survey measurements, the cell contamination of West Valley's operating cell and cell crane. During the cell radiation survey, complete a vertical scan of the melter's lid refractory to estimate the depth to which the cesium salts penetrate the refractory. This information is needed for appropriate design of the LAW lid and shielding. Characterize the vertical radioactivity of spent melter components including vertically along the refractory plug. From the operating and maintenance logs, identify the number and frequency of melter component change outs and other activities that could have led to the existing cell contamination level.</p> <p>Processing Rate: Approaches for increasing processing rates need to achieve or exceed the design basis glass processing rate of 1.5 MT/day (0.4 MT/m²/day), and following thorough evaluation be shown to be preferable to the melt bubbling alternative.</p> <p>Advanced, Corrosion-Resistant Materials: Benchmark materials for consumable melter components and</p>

	glass contact refractories are Inconel 690 and Monofrax K3, respectively. Candidate advanced materials and coatings must have corrosion-resistances that exceed the benchmark materials, and must have similar or appropriate physical properties that impact melter performance (e.g., thermal shock resistance, electrical conductivity).
14	<p>Definition of Solution:</p> <p>Processing Rate: Methods are developed for increasing HLW processing rates without bubbling that on an overall cost/risk/schedule impact basis provide a preferable alternative to bubbling.</p> <p>Advanced, Corrosion-Resistant Materials: Advanced materials, coatings, or passivation schemes will need to be reliably fabricated and/or implemented and should improve the lifetime of melter components by approximately 50% or greater.</p>
15 *	Targeted Focus Area: Tanks Focus Area
16	Potential Benefits: Completion of this task provides a clearer basis for design criteria for melter, other cell and remote handling equipment. These criteria would then support the achievement of the full 40 years of operation design life and better limit personnel exposures.
17	Potential Cost Savings: \$50M to \$300M in operating costs
18	Potential Cost Savings Narrative: Collection of the WVPD data could save an estimated \$1M to \$5M for development, testing, design and construction of potentially unnecessary remote equipment and systems. Successful resolution of the issues stated above could avoid six months to three years delayed production over the 40 year operating life of the facility (\$50M to \$300M in additional operating costs).
	Technical Basis: Current operating vitrification facilities have not collected that data being requested from West Valley.
19	Cultural/Stakeholder Basis: The River Protection Project is committed to moving forward to design, construct, and put into operation the Waste Treatment and Immobilization Plant on the schedule recently agreed to in the Tri-Party Agreement. A robust program is necessary to ensure that delays, all of which are costly, are minimized. A key part of this risk mitigation is to include in the total program a capability to test with actual wastes the processes and equipment planned, or later in use.
20	Environment, Safety, and Health Basis: Reduced operating time and melter cell contamination will result in avoidance of 100 to 1,000 man-rems of exposure.
21	Regulatory Drivers: Environmental Impact Statement (EIS) for the Tank Waste Remediation System (TWRS) (DOE-RL and Ecology 1996) and the Hanford Federal Facility Agreement and Consent Order (known as the Tri-Party Agreement) and its amendments. DOE has negotiated additions to the Tri-Party Agreement that require the retrieval of single shell tanks by 2018, and the startup and operation of the WTP to support the treatment and immobilization of tank waste. By operating the WTP not only is that capability demonstrated and about 10% by volume (25% by activity) of the tank waste processed, but space is made available in the double shell tanks to allow the single shell tank retrieval to proceed without the expenditure of vast sums for additional double shell tanks. Other regulatory drivers include gathering the data necessary for the regulatory permits required for the startup and operation of the facility.
22	<p>Milestones:</p> <p>November 15, 1999 Ttri-Pparty Aagreement on principal regulatory commitments:</p> <ul style="list-style-type: none"> • Start (Hot) commissioning-Phase I Treatment Complex 12/2007 • Start Commercial Operation-Phase 1 Treatment Complex 12/2009 • Complete Phase I-Treatment (no less than 10% of the tank waste by volume and 25% of the tank waste by activity) 12/2018 <p>Other selected TPA milestones are:</p> <ul style="list-style-type: none"> • Retrieve all SSTs 2018 • Close SSTs 2024 • Immobilize remaining tank waste 2028 • Close all tanks 2032

23	Material Streams: ID-3857 HLW to Treatment Risk Score: 3Hanford High-Level Defense Waste. The River Protection Project (formerly known as the Tank Waste Remediation System) involves PBSs RL TW-01 through TW-09. The technical, work scope definition, and intersite dependency risks for Phase 1 Waste Treatment and Immobilization is respectively, 3,3,3 on a scale of 1 to 5 where "5" represents high programmatic risk. This stream is on the critical closure path for Hanford Site cleanup.
24	TSD System: Hanford Waste Treatment and Immobilization Plant. Technical risk is timely startup of this plant and its ability to operate at planned throughput (capacity and operating efficiency).
25	Major Contaminants: Fission products, actinides, nitrate
26	Contaminated Media: Tank waste consisting of supernate (liquid), salt cake, and sludge
27	Volume/Size of Contaminated Media: The Hanford Site has 177 underground tanks that store 204 million liters (54 M gallons) of waste containing about 190 MCi of activity.
28 *	Earliest Date Required: 03/200111/2002 The earliest date required is to support the TPA milestone for Part B Permit Application for Phase I Treatment Complex.
29 *	Latest Date Required: 11/2009 Support Hot Commissioning (which must be completed in 12/2007) and subsequent operation leading to Commercial Operation (which must be started by 12/2009).
Baseline Technology Information	
30	Baseline Technology/Process:
31	Life-Cycle Cost Using Baseline: The current baseline for the WTP is several billion dollars, with the BNI estimate itself is in the \$4 billion range. The current River Protection Project life cycle costs are estimated at approximately \$50 billionThe current baseline for the WTP is several billion dollars, with the BNFL estimate over \$20 billion. The current River Protection Project (formerly known as Tank Waste Remediation Systems) life cycle costs are estimated at approximately \$50 billion.
32	Uncertainty on Baseline Life-Cycle Cost: There is large uncertainty in the WTP life-cycle cost, providing the opportunity to reduce the life-cycle cost due to operation improvements as well as ensuring operational success not to add additional cost to the system.Currently there is large uncertainty in the WTP life-cycle cost, and it will be revised after the new Design and Construction contractor is put under contract early in FY2001.
33	Completion Date Using Baseline: Plant operations will be completed between 2028 and 2040Currently there is large uncertainty in the WTP life-cycle cost, and it will be revised after the new Design and Construction contractor is put under contract early in FY2001.
Points of Contact (POC)	
34	Contractor End User POCs: J.O. (Jim) Honeyman, CH2M Hill Hanford Group, Inc. Tank Waste Treatment Operations; 509-376-7402; F/509-372-1397; email: James_O_Honeyman@rl.gov M.E. (Michael) Johnson, CH2M Hill Hanford Group, Inc. Tank Waste Treatment Operations Research & Technology, 509-372-3628, F/509-376-1788, Michael_E_Johnson@rl.gov
35	DOE End User POCs: R.(R. (Rudy) Carreon, DOE-ORP, 509-373-7771, F/509-373-0628, Rodolfo_Rudy_Carreon@rl.gov E.J. (Joe) Cruz, DOE-ORP, 509-372-2606, F/509-373-1313, E_J_Cruz@rl.gov B.M. (Billie) Mauss, DOE-ORP, 509-373-5113, F/509-372-2781, Billie_M_Mauss@rl.gov R. (Rudy) Carreon, DOE Office of River Protection Project Requirements Division, 509-373-7771, F/509-373-0628, Rodolfo_Rudy_Carreon@rl.gov E.J. (Joe) Cruz, DOE Office of River Protection, 509-372-2606, F/509-373-1313, E_J_Cruz@rl.gov B.M. (Billie) Mauss, DOE Office of River Protection, 509-373-5113, F/509-372-2781, Billie_M_Mauss@rl.gov
36 *	Other Contacts S.A. (Steve) Wiegman, DOE-ORP, 509-372-2536, F/509-372-2781, Stephen_A_Wiegman@rl.gov M.E. (Michael) Johnson, CH2M HILL Hanford Group, Inc., 509-372-3628, F/509-376-1788, Michael_E_Johnson@rl.gov

	M.E. (Michael) Johnson, CH2M Hill Hanford Group, Inc. Tank Waste Treatment Operations Research & Technology, 509-372-3628, F/509-376-1788, Michael_E_Johnson@rl.gov
--	---

*Element of a Site Need Statement appearing in IPABS-IS